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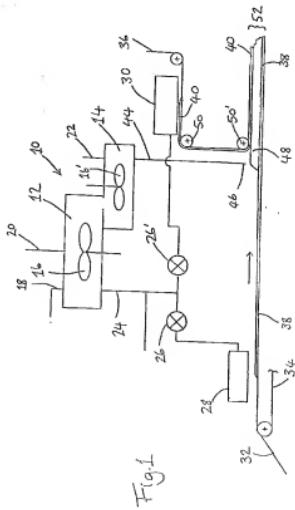
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### (54) A method of manufacturing multilayer plasterboard and apparatus therefor.

(57) The apparatus includes a two-stage mixer comprising a first high shear mixer 12 and a second low shear mixer 14. Plaster slurry is formed in the first mixer; a portion 38 is laid on a first facing sheet 32, a portion 40 B is laid on a second facing sheet 36, and the remainder goes to the second mixer. In the second mixer, foam is added and the formed slurry is laid on the unfoamed slurry on the first facing sheet. The unfoamed slurry on the second facing sheet is brought onto the foamed slurry to form the product.



The invention relates to a method of manufacturing a multilayer plasterboard in which a core layer of the board has a different density from the outer layers, and to apparatus therefor.

The manufacture of a multilayer gypsum plasterboard is disclosed in US 2 940 505. This document discloses the application of thin layers of gypsum plaster slurry to two paper liners. A core layer of gypsum plaster slurry is applied to the first slurry coated liner, and the second slurry coated liner is brought onto the exposed surface of the core. A very satisfactory bond between the liners and the plaster is said to result, even without the use of starch or other adhesive. The apparatus disclosed in US 2 940 505 includes three slurry mixers, supplying gypsum slurry to the two paper liners and the core respectively. In practice, this necessitates complex control systems to ensure synchronicity between the mixes and to ensure that each mixer supplies slurry at the correct rate. The capital and running costs of such an arrangement are high compared to a conventional plasterboard manufacturing line with only one mixer.

According to the present invention there is provided a method for making a multilayer set cementitious product comprising:

- (a) dispersing particulate cementitious material in a liquid medium under conditions of relatively high shear to form a first slurry;
- (b) blending a first portion of the first slurry with foam under conditions of relatively low shear to form a second, foamed, slurry;
- (c) depositing a first layer of one of a second portion of the first slurry and the second slurry on a support; and
- (d) depositing a second layer of the other of the second portion of the first slurry and the second slurry on the surface of the first layer.

In preferred embodiments, the first layer is of the first slurry.

Preferably, a third layer of the same slurry as the first layer is deposited on the second layer. Also preferably, the first and third layers are deposited on facing sheets.

Preferably, the foam is formed prior to blending with the initial dispersion. Preferred foams are formed by incorporating air into a liquid medium.

Additives or other ingredients of the second slurry may be added at any stage, but preferably in step (b), in which the foam is mixed with the first slurry of the particulate material.

The invention also provides apparatus for making a multilayer set cementitious product which comprises: at least one rotary mixer element operative in a first mixing zone and adapted to develop relatively high shear to produce a first slurry of the particulate material, the first zone having inlets for the particulate material and a liquid medium; and at least one rotary mixer element operative in a second mixing zone of

relatively low shear in direct communication with the first mixing zone, the second mixing zone being provided with an inlet for a foam component and an outlet for the second, foamed, slurry of particulate material, and the first zone having a second outlet for the first slurry.

If a preformed foam is employed, the inlet to the second zone is an inlet for the performed foam. Inlets, may additionally be provided for additives or other ingredients, usually solid, of the slurries.

A preferred embodiment of the invention comprises: a first mixing chamber containing a first mixing rotor adapted to be driven at a relatively high speed and having inlets for the particulate material and for a liquid (such as water) and first and second outlets for the resulting first slurry; a second mixing chamber containing a second mixing rotor adapted to be driven at a lower speed than the first mixing rotor and having inlets for the first slurry of the particulate material and for a foam component and an outlet for the second, foamed, slurry, the first outlet of the first mixing chamber being disposed to deliver the first slurry directly into the corresponding inlet of the second mixing chamber.

The relatively high shear in the first mixing zone or chamber is preferably developed by rotating the mixing chamber in the first mixing zone at a peripheral speed of 10-50 m/s. Where the second mixing rotor is provided in the second mixing zone it is preferably rotated at a peripheral speed in the range of 0.1 to 10 m/s. Preferably the shear rate in the first zone is at least 5 times as great as in the second zone and may be 30 times more as great. It is preferred that the inlets for the particulate material and the liquid in the first mixing zone should be at smaller radial distances from the rotational axis of the mixing rotor than the outlet for the first slurry. Similarly it is preferred that the inlets for the first slurry and the foam in the second mixing zone should be radially less distant from the axis of rotation of the mixing rotor than the outlet for the aerated slurry. In both cases, this means that the input is in a relatively low energy region of the mixer and the output from a relatively high energy region.

Preferred apparatus according to the invention further comprises: a support for slurry; a first slurry application station adjacent the support and in communication with one of the first outlets from the first zone or chamber and the outlet from the second zone or chamber, the first station comprising a slurry outlet and a spreader for spreading slurry on the support; and a second station adjacent the support and in communication with the other of the said outlets, the second station comprising a slurry outlet and a spreader for spreading slurry on the support. Preferably, a third station is in communication with the same zone or chamber as the first station. In a preferred embodiment, the first and third stations are in communication with the first outlet from the first zone or chamber, so

that the outer layers of the finished plasterboard are unfoamed.

The invention will be further described, by way of example, with reference to the accompanying drawings, in which:

Figure 1 shows diagrammatically a preferred apparatus according to the invention;

Figure 2 shows a section through a board made by the invention; and

Figure 3 shows a second through a preferred mixer according to the invention.

The apparatus shown diagrammatically in Figure 1 comprises a two-stage mixer 10, comprising a first, high shear, mixing chamber 12 and a second, low, shear, mixing chamber 14, each having a rotor 16, 16' for mixing the contents. Water and stucco are supplied continuously to the first chamber 12 through inlets 18, 20. The water and stucco are subjected to high shear mixing conditions by rotor 16. Some of the resulting slurry passes directly from the first chamber 12 to the second, low shear, chamber 14. A preformed foam is also supplied to the second chamber through an inlet 22. The foam is blended with the slurry under conditions of low shear to produce a foamed slurry.

The slurry from the first chamber 12 which does not pass directly into the second chamber leaves the first chamber through outlet 24, and is pumped by pumps 26, 26' to first 28 and third 30 slurry deposition stations. At the first station, the slurry is deposited and spread by air knives on a liner paper 32 carried on a continuous belt 34, the return run of which is shown in Figure 1. In an alternative embodiment, spreading is achieved with rollers, rather than air knives. The upper run of the belt 34 travels in the direction shown by the arrow in Figure 1. Similarly, at the third station 30, the slurry is deposited and spread on a second liner paper 36. Thus, layers 38, 40 of the unfoamed slurry on liner paper are formed. In order to assist adhesion of the slurry to the liner papers, starch may be added to the slurry through an inlet 42 immediately upstream of the pumps 26, 26'.

The foamed slurry formed in the second chamber 14 leaves the second chamber through an outlet 44 which leads the foamed slurry to a second slurry deposition station 46, which is a conventional slurry outlet.

The continuous belt 34 carries the first liner paper 32 with the first layer 38 of slurry thereon from the first station 28 to the second station 46. At the second station, foamed slurry is deposited and spread on the layer 38 of unfoamed slurry to form a foamed slurry layer 48. The second liner paper 36 carrying the layer 40 of unfoamed slurry is passed over two rollers 50, 50' each of which turns the paper through 90° to reverse the liner paper so that the unfoamed slurry layer 40 is below the liner paper rather than above it, as it was formed. As the liner paper 36 passes around the second roller 50', the slurry layer 40 comes into con-

tact with the foamed slurry layer 48 on the belt 34. In an alternative embodiment, the unfoamed slurry is deposited on the vertical run of the second liner paper 36 between the two rollers 50, 50'.

5 The plaster is then set and dried in a conventional manner, to provide a gypsum board 52 as shown in Figure 2 having a lightweight foamed core 48' between denser unfoamed layers 38', 40', faced on both sides with liner paper 32, 36. By using the method and apparatus of the invention, the outer layers 38', 40' may be as much as 50% or more denser than a conventional plasterboard boards. 10 These layers are typically at least 0.5mm in thickness and are preferably 1mm thick and the foamed core is typically 10mm thick.

15 Figure 3 shows a preferred mixer 10. As shown, it comprises a first mixing chamber 12 formed from a top wall plate 110, a bottom wall plate 112 and a cylindrical side wall 114. For cleanliness of operation these are preferably made of stainless steel although other materials may be used. A disc shaped mixing rotor 16, preferably also of stainless steel, is mounted 20 on a rotatable shaft 116 which is supported by bearings 118 and passes in liquid-tight manner through the bottom wall 112. The top of the shaft and the central area of the rotor are covered by a conical deflector 120.

25 An inlet 20 for stucco is provided in the top wall 110, preferably in a central or axial position. A further inlet 18 for water is also provided in the top wall, approximately midway between the stucco inlet 20 and the outer periphery of the mixing chamber 12. A first outlet 122 for the slurry formed in the first mixing chamber is provided in the bottom wall 112, preferably in the outermost region thereof, and in the vicinity of the side wall 114. A second outlet 24 is provided diametrically opposite the first outlet.

30 Top scrapers 124 are mounted radially on the top of each rotor, being supported at the outer edge of the rotor and extending inwards to the edge of the stucco inlet 20. Bottom scrapers 126 are mounted radially on the under surface of the rotor 16. The scrapers are adjusted to give minimal clearance with the respective walls.

35 The surface of the rotor can be provided with pegs or teeth, for example round the periphery, but this has not been found necessary in the case of preparing slurries of gypsum plaster.

40 The apparatus shown in the drawings includes a second mixing chamber 14 which similarly comprises top 128 and bottom 130 walls and a cylindrical side wall 132. The top wall 128 may be formed from the same plate as the bottom wall 112 of the first mixing chamber 10.

45 A second mixing rotor 16' is mounted on a shaft 134 in similar manner to the rotor in the first mixing

chamber 12 and may likewise be provided with top and bottom scrapers 136,138. The top scraper 136 may conveniently extend continuously across the top of the chamber because there is no central inlet for particulate material in the second chamber 14. The rotor has a similar clearance with the side wall 132 and the scrapers similar clearances with the top 128 and bottom 130 wall respectively, as in the first mixing chamber.

The first outlet 122 from the first chamber constitutes the inlet to the second chamber for the unfoamed slurry, and the top wall 128 is also formed with an inlet 22 for previously formed aqueous foam. An outlet 44 for the foamed slurry is provided in the outer region of the bottom wall 130 in close proximity to the side wall 132.

In operation, plaster or stucco is supplied continuously through the inlet 20 and water through the inlet 18. These meet on the upper surface of the rotor element 16, where they are mixed and passed between the rotor and the side wall 114. Some of the resulting slurry passes through the first outlet 122 into the second chamber 14, falling on the upper surface of the rotor 16', where it meets preformed foam entering through the inlet 22. The slurry and the foam are mixed together under lower shear conditions than those prevailing in the first mixing chamber 12, whereby uniform distribution of the incorporated air is achieved with minimal separation of air into significant voids.

The proportion of unfoamed slurry leaving the first mixing chamber 12 by the first outlet 24 to go directly to a slurry application station without foaming will depend upon the relative thickness of the foamed and unfoamed layers in the finished plasterboard and on the degree of foaming to which the foamed slurry is subject. Typically, about 25% by volume of the contents of the first mixing chamber 12 will leave it by the first outlet 24 and will not be foamed.

When, as is commonly the case, additives and other ingredients are employed, for example, lightweight aggregate, reinforcing fibre, setting accelerator and starch, these may be added at either stage through specially provided inlets. If an additive is required in both the foamed and unfoamed slurry, it is preferably added to the first chamber 12. If it is required only in the unfoamed slurry, it can be added to the unfoamed slurry after it has left the first chamber, and if it is required only in the foamed slurry it can be added to the second chamber 14.

Surprisingly, it has been found advantageous to have the second mixing chamber 14, of smaller capacity than the first mixing chamber 12, despite the increased volume (due to the addition of foam) of the contents of the second chamber compared to those of the first chamber. The residence time in the second stage is thus kept very short, so that the total residence time in the complete mixer will be comparable with that in a single stage mixer of the prior art.

The portion of the unfoamed slurry formed in the first chamber 12 which does not pass into the second chamber 14 passes out of the second outlet 24 to the pumps 26, 26' (Figure 1) and thence to the first 28 and third 30 deposition stations. The foamed slurry formed in the second chamber 14 leaves that chamber through the outlet 44 therefrom and passes to the second deposition station 46. As previously described, a first layer 38 of unfoamed slurry is deposited and spread on a first liner paper 32 on the continuous belt 34 at the first station 28, and a second layer of foamed slurry is deposited and spread on the first layer 38 at the second station 46. Unfoamed slurry is also spread, at the third station 30, on a second liner paper 36 to form a third layer 40.

The second liner paper 36 is then reversed, and the third layer 40 is brought onto the second layer 48 to form the three-layered product shown in Figure 2.

## 20 Claims

1. A method for making a multilayer set cementitious product comprising:
  - (a) dispersing particulate cementitious material in a liquid medium under conditions of relatively high shear to form a first slurry;
  - (b) blending a first portion of the first slurry with foam under conditions of relatively low shear to form a second, foamed, slurry;
  - (c) depositing a first layer (38) of one of a second portion of the first slurry and the second slurry on a support (32); and
  - (d) depositing a second layer (48) of the other of the second portion of the first slurry and the second slurry on the surface of the first layer.
2. A method according to claim 1 in which the first layer is of the first slurry.
3. A method according to claim 1 or 2 in which a third layer (40) of the same slurry as the first layer (38) is deposited on the second layer (48).
4. A method according to claim 3 in which the third layer (40) is deposited on a facing sheet (36) and the coated sheet is applied to the surface of the second layer (48) such that the second and third layers are in contact.
5. A method according to any preceding claim in which the support (32) is a facing sheet.
6. A method according to any preceding claim in which the support (32) is continuously advanced from a first station where the first layer (38) is deposited to a second station where the second layer (48) is deposited.

7. A method according to any preceding claim in which the foam is formed prior to blending with the initial dispersion.

8. A method according to any preceding claim in which at least one additive or other ingredient is added in step (b).

9. A method according to any preceding claim in which steps (a) and (b) are conducted in separate mixing chambers (12) (14), the first portion of the initial dispersion produced by step (a) being directly and continuously transferred to step (b).

10. A method according to any preceding claim in which the particulate material is capable of reacting with the liquid medium.

11. A method according to claim 10 in which the particulate material is gypsum plaster or stucco and the liquid medium is water.

12. Apparatus (10) for making a multilayer set cementitious product which comprises: at least one rotary mixer element (16) operative in a first mixing zone (12) and adapted to develop relatively high shear to produce a first slurry of the particulate material, the first zone having inlets (18) (20) for the particulate material and a liquid medium; and at least one rotary mixer element (16) operative in a second mixing zone (14) of relatively low shear in direct communication (122) with the first mixing zone, the second mixing zone being provided with an inlet (22) for a foam component and an outlet (44) for the second, foamed, slurry of particulate material, and the first mixing zone having a second outlet (24) for the first slurry.

13. Apparatus according to claim 12 including inlets for additives or other ingredients in the portion of apparatus providing the second mixing zone (14).

14. Apparatus according to claim 12 or 13 which comprises: a first mixing chamber (12) containing a first mixing rotor (16) adapted to be driven at a relatively high speed and having inlets (18) (20) for the particulate material and for a liquid and first and second (24) outlets for the resulting first slurry; a second mixing chamber (14) containing a second mixing rotor (16) adapted to be driven at a lower speed than the first mixing rotor and having inlets (22) for the first slurry of the particulate material and for a foam component and an outlet (44) for foamed slurry, the first outlet (122) of the first mixing chamber being disposed to deliver the first slurry directly into the correspond-

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ing inlet (122) of the second mixing chamber.

15. Apparatus according to claim 14 wherein the first mixing rotor (16) is a disc mounted for rotation about an axis passing substantially perpendicular through its centre.

16. Apparatus according to claim 14 or 15 wherein the second mixing chamber (14) is of smaller volume than the first mixing chamber (12).

17. Apparatus according to any of claims 12 to 16 further comprising: a support for slurry (32); a first slurry application station (28) adjacent the support and in communication with one of the second outlet (24) from the first zone or chamber (14) and the outlet from the second zone or chamber, the first station comprising a slurry outlet and a spreader for spreading slurry on the support; and a second station (46) adjacent the support and in communication with the other of the said outlets (24) (44) the second station comprising a slurry outlet and a spreader for spreading slurry.

18. Apparatus according to claim 17 further comprising means (34) for continuously advancing the support from the first to the second station.

19. Apparatus according to claim 18 in which the first station (28) is in communication with the second outlet (24) from the first zone or chamber (12) and the second station (46) is in communication with the outlet (44) from the second zone or chamber (14).

20. Apparatus according to claim 17, 18 or 19 further comprising: a third station (30) in communication with the same outlet (24) (44) as the first station (28); means (50, 50) for passing a continuous facing sheet (36) adjacent the third station, the third station comprising a slurry outlet and a spreader for spreading slurry on the facing sheet; and means (50, 50) for bringing the coated surface of the facing sheet toward and into contact with slurry on the support.

21. Apparatus according to any of claims 12 to 20 in which the Inlet (22) into the second zone or chamber (14) is an inlet for a previously formed foam.

22. Gypsum plasterboard comprising an inner core (48') of foamed gypsum plaster and outer layers (38' 40') of unfoamed gypsum plaster, the outer layers being at least 0.5mm thick.

23. Gypsum plasterboard according to claim 22 in which the outer layers (38' 40') are at least 1mm thick.

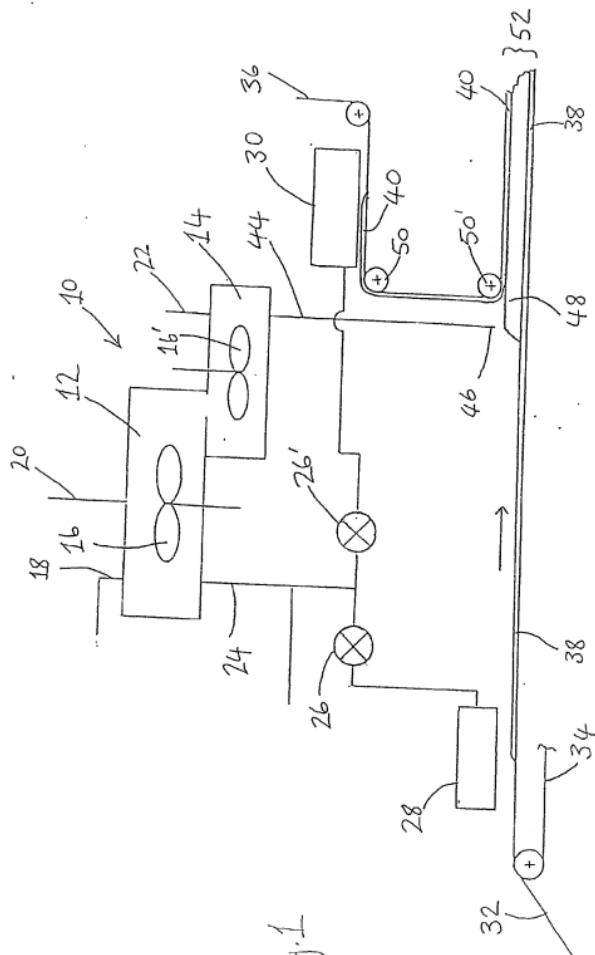


Fig. 1

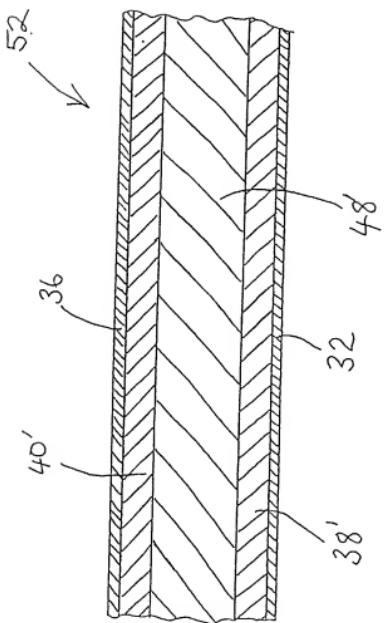
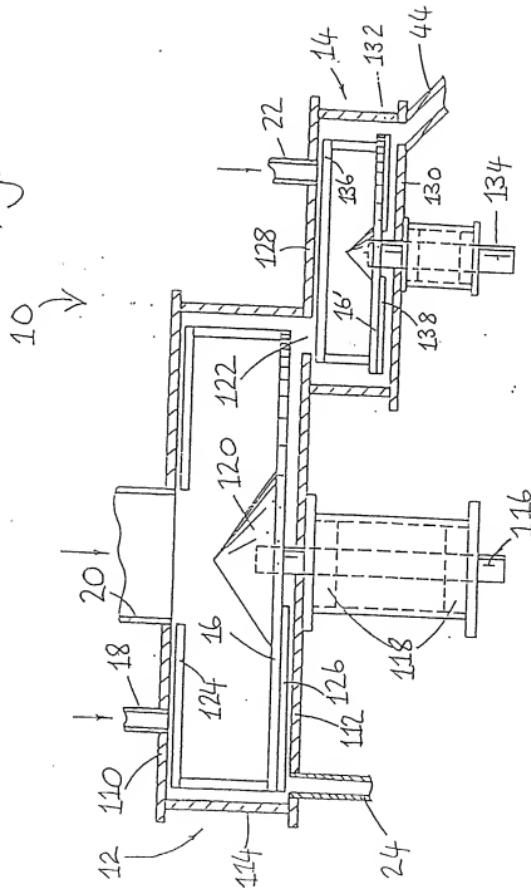


Fig 2

Fig. 3





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## EUROPEAN SEARCH REPORT

Application Number  
EP 94 30 4998

## DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.)
X	WO-A-93 03899 (BABCOCK-BSH AG)  * the whole document , in particular page 16 , line 5 - page 16 , line 37 ; figure 2 *	1-6, 8-13, 17-20, 22,23	B28B1/16 B28B17/02
Y	---	7,14-16, 21	
Y	US-A-2 985 219 (J. M. SUMMERFIELD)  * the whole document *	7,14-16, 21	
A	---	1-6, 8-13, 17-20, 22,23	
Y	US-A-4 279 673 (G. H. WHITE)  * the whole document *	7,14-16, 21	
A	---	1-6, 8-13, 17-20, 22,23	TECHNICAL FIELDS SEARCHED (Int.Cl.)  B28B
A	EP-A-0 153 588 (" WÜRTEX " MASCHINENBAU HOFMANN GMBH & CO)  * page 7, line 32 - page 8, line 4 * * page 11, line 29 - page 13, line 31 * * page 15, line 17 - page 17, line 17 * * figures 1,3B-3E *	1-23	
The present search report has been drawn up for all claims			
Place of search	Date of completion of the search	Examiner	
THE HAGUE	25 October 1994	Gourier, P	
CATEGORY OF CITED DOCUMENTS			
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